



**BOEING REALTY CORPORATION
FORMER C-6 FACILITY
LOS ANGELES, CALIFORNIA**

**TECHNICAL MEMORANDUM
BUILDING 2 BIOREMEDIATION SYSTEM CONSTRUCTION
LESSONS LEARNED**

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From: Haley & Aldrich, Inc.

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Subject: Boeing Realty Corporation, Former C-6 Facility, Building 2 Bioremediation System Construction Lessons Learned

The design and installation of the subsurface bioremediation system at the former C-6 facility involved coordination and planning between Boeing, Haley & Aldrich, Arcadis, Integrated Construction Services (ICS), Oltmans, Thienes Engineering, and various drilling companies. The construction activities required several contractors to work very closely with and near each other to meet the very aggressive schedule and avoid deadline-driven liquidated damages. Lessons learned during this challenging construction project are presented below to aid the involved parties with any similar construction projects in the future.

DESIGN/SOLICITATION

- Meet with Owners architect as early as possible in design process. The Boeing design team was not introduced to the Owner's design team until significant building and subsurface design was completed. This resulted in the Boeing Design Team adjusting the physical the physical location of piping and wells and installing systems deeper to go under footings/foundations and utilities rather than through or over them respectively. The architect also needed to redesign portions of the perimeter foundation to accommodate our required piping pass-throughs.
- Obtain pre-approval of vault number and locations from the owner and owner's architect prior to initiating the detailed design. Significant design costs can be saved by not having to re-design, move, and/or combine vaults.
- Strive to locate vaults in landscape areas. This has the advantages of lower installation costs due to non-traffic rating and easier access since vehicles will not be parked on top of well vaults.
- Vault locations should be planned and designed such that tanker trucks have easy access and not hinder traffic patterns of the owner/tenant. This will further minimize pre-injection coordination.

- Areas where tanker trucks will be performing injections need to be designed to accommodate the maximum potential weight of the tanker trucks and not cause potential pavement deformation.
- A water spigot should be incorporated in an easy access location for injection maintenance and decontamination. The sizing of the spigot shall take into consideration all of the potential water needs of the project/task.
- Verify if any permits are needed from the City Building Department for the installation of the remediation system. If yes, discuss if the permitting will be done in conjunction with the overall building permit by the owner or the permitting will be obtained by the Boeing contractor.
- Identify materials that are unique or have long delivery time frames. Prioritize these for ordering or identify alternate materials for use.

DRILLING PROGRAM

- The minimum CPT rig weight required to consistently achieve the target depths (up to 85-90 ft) is 28 to 30 tons.
- Consider having a hollow stem auger rig on standby, because it can provide a critical safety net during a tight schedule when the CPT rigs are unable to push to the required depths.
- Pre-punching the boring with a smaller diameter rod prior to pushing for injection point installation helped one of the drillers achieve the targeted maximum depth.
- After pushing the first 20 feet, reduce the rod diameter from 2 ¼ inch to 1 ½ inch to decrease frictional drag. This process helped one of the drillers achieve the targeted maximum depth.
- Mix fresh grout immediately prior to emplacing in the boring, because old grout can result in increased pressure test failures.
- Barricade/tape off the drilling area and place delineators and flagging on each well before driving away. This duplicative system is critical to avoid other contractors from inadvertently damaging injection points before they are cut-off and buried.
- Have a clearly-defined well testing program/SOP. The installation contractor shall verify that the well has been installed in accordance with the specifications. Monitoring wells shall meet groundwater quality standards prior to stopping purging. Injection wells shall meet pressure and flow specifications without seal failure.
- Have drilling contracts written that requires well re-installation at the drillers cost if an injection well does not pass the injection test or a monitoring well does not develop due to poor construction or broken casing.
- Negotiate the longest construction time possible. Coordination of multiple drilling rigs and payment for stand-by is costly if required.

CONSTRUCTION PROGRAM

- Both straight length sections (i.e. 40 foot pieces) and long continuous rolls (i.e. 500 foot long) of HDPE piping can be used successfully. The rolled pipe works best when you have long runs branching off the main trench with 4 or less pipes. The straight length section works best on the long straight main trunk where there are 10 to 16 pipes in each layer.
- The straight sections cost approximately 15-20% more due to the added coupling and manufacturing costs. Also, it can be difficult to find a manufacturer to mold the straight sections, especially on short notice and for small quantity projects.
- Whenever possible, install the HDPE pipe lines AFTER every other utility has been installed by all other trades/contractors. This minimizes the amount of excavating and helps to prevent other trades/contractors from damaging installed HDPE lines.
- Encasing the HDPE piping in slurry is the best way to go, even though it provides little protection from accidental excavation. It has great utility and provides quick, compact backfill that easily passes between the HDPE piping in the trenches. Concrete should be considered in locations where future excavations (by others) are expected, in order to help protect them from accidental excavation/damage.
- Avoid using the same project surveyor as the building general contractor, because it can result in scheduling problems due to unavailability and priorities. Further, one surveyor is insufficient when a large number of survey points are needed by the owner and Boeing in a short time frame. It can also lead to billing confusion and difficulty separating data belonging to the various contractors.
- Have a contingency plan in place if remediation piping is damaged. The contingency plan would include reporting, documentation, repairs, and post-repair testing.
- Maintain, to the extent possible, multiple means of underground line mark-out. Methods that were used on site included PK nails with utility brushes, caution tape nailed to the soil, spray paint, and delineators. Delineators are a poor means of mark-out since they can easily be moved.
- All trenches should be completed with a locator tape/wire so that the trench and piping can be easily located after backfilled. The wire allows for easy location of plastic subsurface piping.


OVERSIGHT AND PROJECT MANAGEMENT

- Continuity of project management and project team members is very helpful. Having the same project managers from Haley & Aldrich, Arcadis, and ICS involved from the design/bidding process through the completion of construction made it easy to build a strong team and communicate effectively together. It also helped to ensure that concerns and details identified during the design and bidding phases were successfully addressed and implemented during the construction phase.

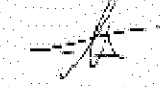
- Weekly team meetings were very helpful in keeping the team members integrated, identifying and addressing new issues before they became problems, and keeping Boeing informed of the project progress and issues.
- Full-time oversight during subsurface work is strongly recommended due to the number of parties involved, including the general building contractor and their subcontractors. The general building contractor often knows little about the actual daily activities of their subcontractors. Having someone on-site to coordinate and observe our construction activities and the activities of others can help avoid schedule delays and damage to the bioremediation system.
- The general building contractor and their subcontractors cannot be relied upon to keep good as-built drawings, and not every excavation and/or utility will be on a drawing. Drawings, field walks, and meetings with all the other contractors is critical to help avoid damage to their utilities and/or our bioremediation system. Constant communication in the field is the key.
- Maintain a 2-3 day detailed rolling schedule of site construction activities and a list of contractors working.
- Conduct a daily meeting with the owner's construction superintendent to review where Boeing is working and review where they are working. The meeting should include a walk of the work areas pointing out potential work area conflicts and discussing field measures to resolve the conflicts.

Should you have any questions concerning the contents of this memorandum or require additional information, please contact either of the undersigned.

Sincerely yours,
HALEY & ALDRICH, INC.


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Senior Engineer




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